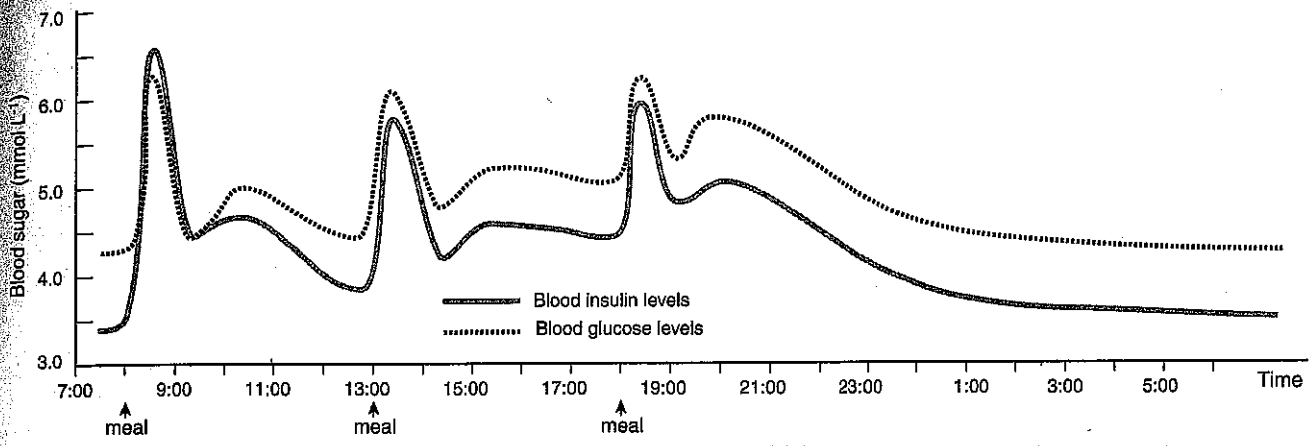
Control of Blood Glucose

The endocrine portion of the **pancreas** (the α and β cells of the **islets of Langerhans**) produces two hormones, **insulin** and **glucagon**, which maintain blood glucose at a steady state through **negative feedback**. Insulin promotes a decrease in blood glucose by promoting cellular uptake of glucose and synthesizing glycogen. **Glucagon** promotes an increase in blood glucose through the breakdown of glycogen and the synthesis of glucose from amino acids. When normal blood glucose levels are restored, negative feedback stops hormone secretion. Regulating blood glucose to within narrow limits allows energy to be available to cells as needed. Extra energy is stored as glycogen or fat, and is mobilized to meet energy needs as required. The liver is pivotal in these carbohydrate conversions. One of the consequences of a disruption to this system is the disease **diabetes mellitus**. In type 1 diabetes, the insulin-producing β cells are destroyed as a result of autoimmune activity and insulin is not produced. In type 2 diabetes, the pancreatic cells produce insulin, but the body's cells become increasingly resistant to it.



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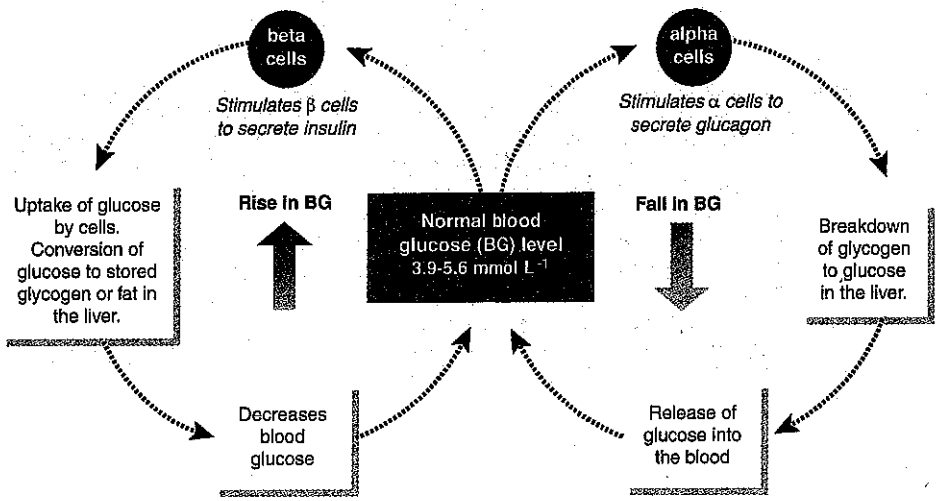
In type 1 diabetes mellitus, the β cells of the pancreas are destroyed and insulin must be delivered to the bloodstream by injection. Type 2 diabetics produce insulin, but their cells do not respond to it.

Negative Feedback in Blood Glucose Regulation



1. (a) Identify the stimulus for the release of insulin: _____

   (b) Identify the stimulus for the release of glucagon: _____

   (c) Explain how glucagon brings about an increase in blood glucose level: _____

   _____

   (d) Explain how insulin brings about a decrease in blood glucose level: _____

   _____

2. Explain the pattern of fluctuations in blood glucose and blood insulin levels in the graph above:

   _____

   _____

   _____

   _____

3. Identify the mechanism regulating insulin and glucagon secretion: _____

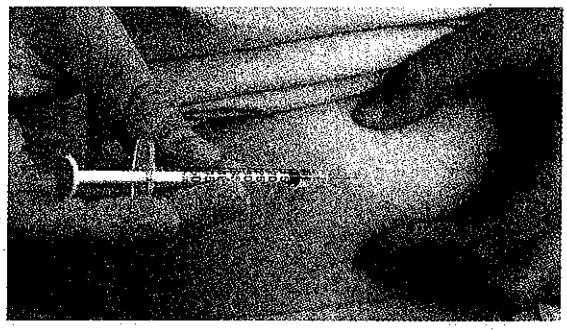
Type 1 Diabetes mellitus (insulin dependent)

Deficient Insulin Production

Age at onset: Early in life; often in childhood (type 1 diabetes mellitus is often called juvenile onset diabetes).

Cause: Absolute deficiency of insulin due to lack of insulin production (pancreatic β cells are destroyed in an autoimmune reaction). There is a genetic component but usually a childhood viral infection triggers the development of the disease. Mumps, coxsackie, and rubella are implicated.

Treatment: Blood glucose is monitored regularly and insulin injections combined with dietary management have been used to keep blood sugar levels stable. New therapies involving transplants of insulin-producing islet cells have been used with varying degrees of success. In the future, the option of gene therapy, where the gene for insulin production is inserted into the patient's cells, may be possible.



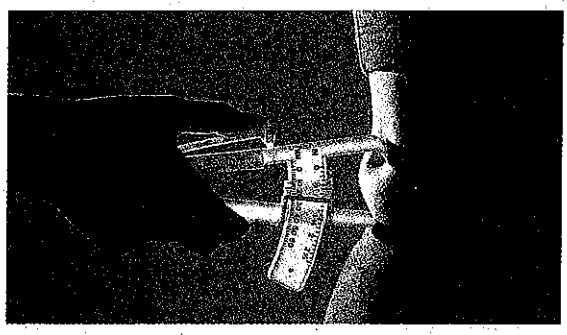
Type 2 Diabetes mellitus (insulin resistant)

Deficient Insulin Response

Age at onset: Historically, type 2 diabetes mellitus has usually occurred in adults over the age of 40, but its incidence is increasing in younger adults and obese children.

Cause: Type 2 diabetes may have a genetic component (in susceptibility), but it occurs most commonly as a result of lifestyle factors. Obesity (BMI > 27), a sedentary lifestyle, hypertension, high blood lipids, and a poor diet all contribute to make a person more susceptible to developing type 2 diabetes. Ethnicity may also be a contributing factor.

Treatment: Increasing general physical activity, losing weight (especially abdominal fat), and improving diet may be sufficient to control type 2 diabetes in many cases. The use of prescribed anti-diabetic drugs and insulin therapy (injections) may be required if lifestyle changes are insufficient on their own.

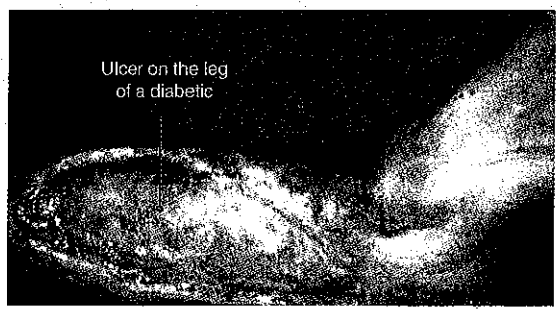


The Effects of Diabetes Mellitus

Diabetes has several effects on the body. Glucose is used by cells for energy. Low insulin or insulin resistance results in low glucose within the cell. This effectively causes starvation within the cell, causing it to metabolize fats for energy. Fat metabolism produces ketones as a by-product, which can build up in the blood and cause **ketoacidosis**, with lowers the pH of the blood and can result in death.

Fats moving through the blood to places of metabolism can stick to or irritate the walls of blood vessels and cause cardiovascular diseases, such as atherosclerosis.

High blood glucose also causes irritation and damage to blood vessels and to nerves. Results include numbness or tingling, loss of vision as retinal cells are damaged, gangrene and failure or wounds to heal.



4. Explain briefly why diabetes mellitus results in hyperglycaemia (high blood sugar levels): _____

5. Discuss the differences between type 1 and type 2 diabetes, including causes and treatments: _____

6. Explain why the increase in type 2 diabetes is considered epidemic in the developed world: _____

7. Describe some effects of high glucose levels in the blood: _____